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Bimonthly Progress Report for 1 May to 1 July 1962

THERMOELECTRIC MATERIALS

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I INTRODUCTION

This Progress Report describes the work performed under Contract NObs-77017 (Index Number NS-058-001) on thermoelectric materials for the period 1 May to 1 July 1962 and outlines the proposed effort for the next period.

II WORK PERFORMED

Cuprous Sulfide-Cuprous Telluride -- Measurements have been made to determine the Seebeck coefficient and resistivity for the sample of 75% cuprous telluride and 25% cuprous sulfide used by Westinghouse to measure the liquid thermal conductivity. The procedure used was to melt the entire sample received in order to homogenize it and quick-cool the sample to prevent segregation on solidification. The entire sample was then ground in a mortar to a powder, mixed well, and a portion removed and placed in the cell for measurement of the Seebeck coefficient and resistivity. Table I presents the experimental values obtained. For purposes of comparison the corresponding values obtained for this composition prior to the thermal conductivity measurements at Westinghouse are included. Because of the wide variation of the initial and final measurements on this sample, a second preparation of this composition was made from the elements and the Seebeck coefficient and resistivity were determined. From an examination of Table I it is evident that the differences between the initial and final values of these parameters for the thermal conductivity specimen are much greater than the variation between the two preparations, particularly in the resistivity.

As was stated in Report No. 19 the sample on which the thermal conductivity measurements had been performed contained a large amount of copper whiskers. Excess copper in cuprous sulfide tends to lower the Seebeck coefficient of the liquid and to lower the resistivity to a

Table I

THERMAL CONDUCTIVITY SAMPLE								RECENT PREPARATION			
INITIAL				FINAL							
T (°C)	S(μv/°C)	T (°C)	ρ(Ω cm x 10³)	T (°C)	S(μv/°C)	T (°C)	ρ(Ω cm x 10³)	T (°C)	S(μv/°C)	T (°C)	ρ(Ω cm x 10³)
1219	+165	1211	1.53	1208	+146	1201	3.13	1208	+148	1201	1.57
1183	170	1176	1.55	1168	155	1164	3.19	1164	159	1159	1.54
1156	169	1150	1.56	11[illegible]1	164	1114	3.78	1122	157	1115	1.58
1131	172	1124	1.57	1116	165	1110	3.51	1093	158	1088	1.54
1110	169	1099	1.57	1084	171	1080	4.08	1071	163	1069	1.54
1080	172	1075	1.58	1077	178	1069	4.16	1047	158	1041	1.58
1054	175	1048	1.58	1067	180	1061	3.95	1042	165	1036	1.54
1032	175	1023	1.58	1042	190	1034	4.22	1019	166	1012	1.54
1007	175	1000	1.58	1031	193	1011	3.95	1000	158	991	1.56
976	172	965	1.58	1013	196	1010	4.58	974	165	970	1.53
960	173	950	1.57	995	195	989	5.37	952	162	946	1.38
941	175	928	1.48	958	258	950	5.36	937	159	930	1.20
917	166	905	1.25	928	263	920	5.10	914	150	906	0.96
889	151	875	1.03	905	265	898	4.98	895	148	889	0.88
863	137	850	0.87	877	268	369	4.79				
817	123	825	0.77	842	260	835	4.57				
		814	0.75	758	243	751	3.92				
		805	0.72								

smaller extent. However, the effect in this composition has been to raise the Seebeck coefficient slightly at the lower temperatures and to raise the resistivity by a factor of between 2 and 3 over the liquid range. Reasoning by analogy with the copper-sulfur system one would conclude that other changes, in addition to loss of tellurium, must have occurred. A possible explanation lies in oxide formation during the prolonged heating for the thermal conductivity measurements. Figure 1 shows the extent of modification in the Seebeck coefficient and resistivity which occurred. In addition the quantity S^2/ρ is plotted for the three sets of measurements.

The smoothed values for the liquid thermal conductivities of 75% Cu_2Te and 25% Cu_2S have been received from Dr. E. W. Johnson of Westinghouse. Using these values a value for ZT may be calculated for this composition. These are considerably lower than estimated from preliminary data, primarily because of the increase in resistivity observed in the final measurements. However, neither the loss in tellurium nor the formation of oxide should modify extensively the "lattice" thermal conductivity of the liquid, and therefore it is a good approximation to use the measured values of the conductivity with the values of the Seebeck coefficient and resistivity as determined prior to the conductivity determination. Table II presents the quantity ZT for the three sets of measurements and Figure 2 shows the same information graphically.

Table II

T (°C)	ZT for 25% Cu_2S 75% Cu_2Te		
	Initial	Final	Recent
1200	1.27	0.49	1.06
1150	1.38	.54	1.18
1100	1.52	.63	1.32
1050	1.73	.73	1.48
1000	1.98	.86	1.72

Bismuth-Sulfur System -- Work on this system was halted in order to examine the cuprous telluride-cuprous sulfide samples and complete this phase as rapidly as possible.

III WORK PLANNED 1 JULY TO 1 SEPTEMBER 1962

Work will be continued on the bismuth-sulfur system, and its mixtures with cuprous sulfide will be examined.

IV CONTRIBUTORS

Mr. G. Withers and Dr. J. W. Johnson prepared various compositions and made electrical measurements.

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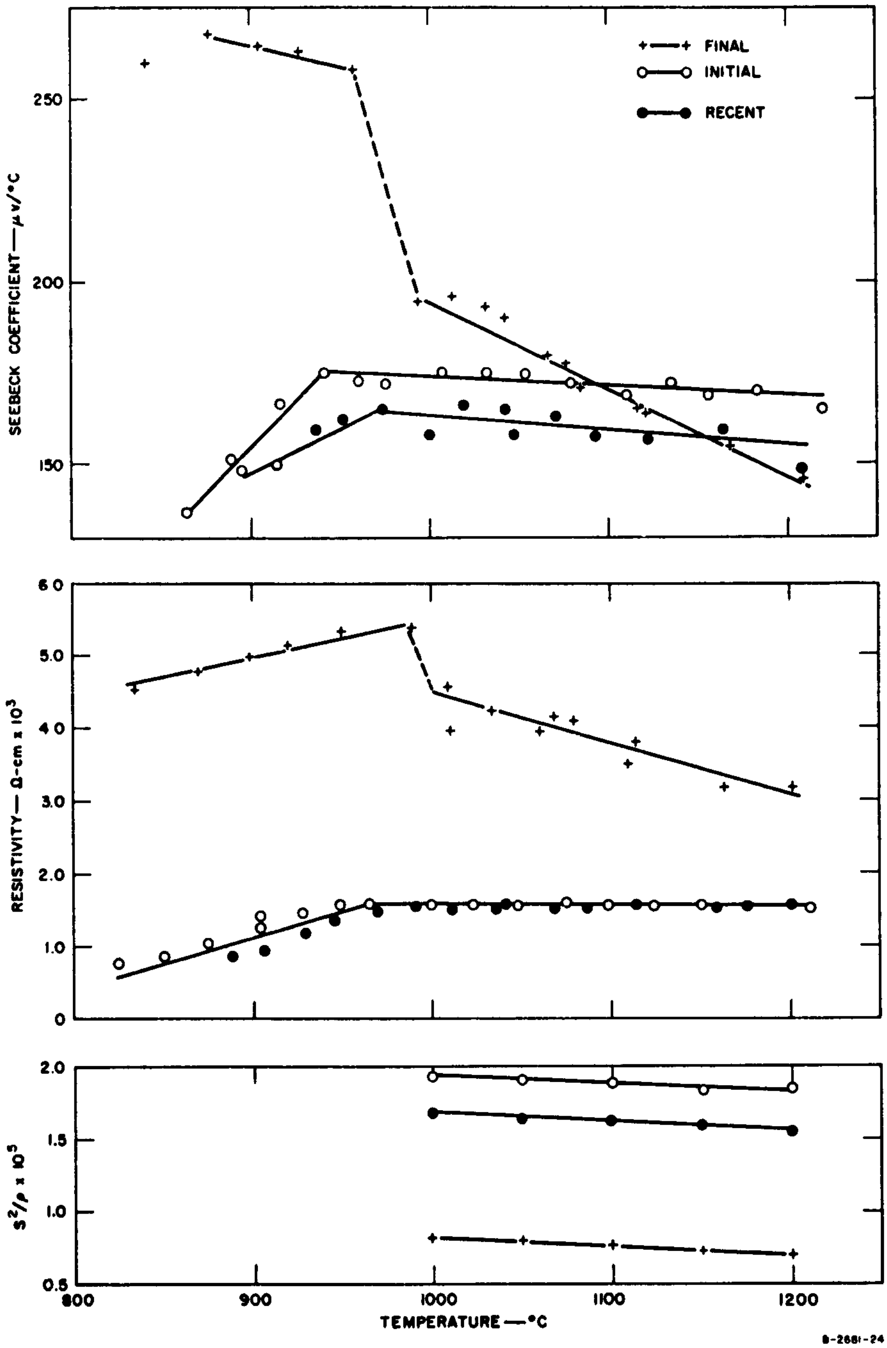
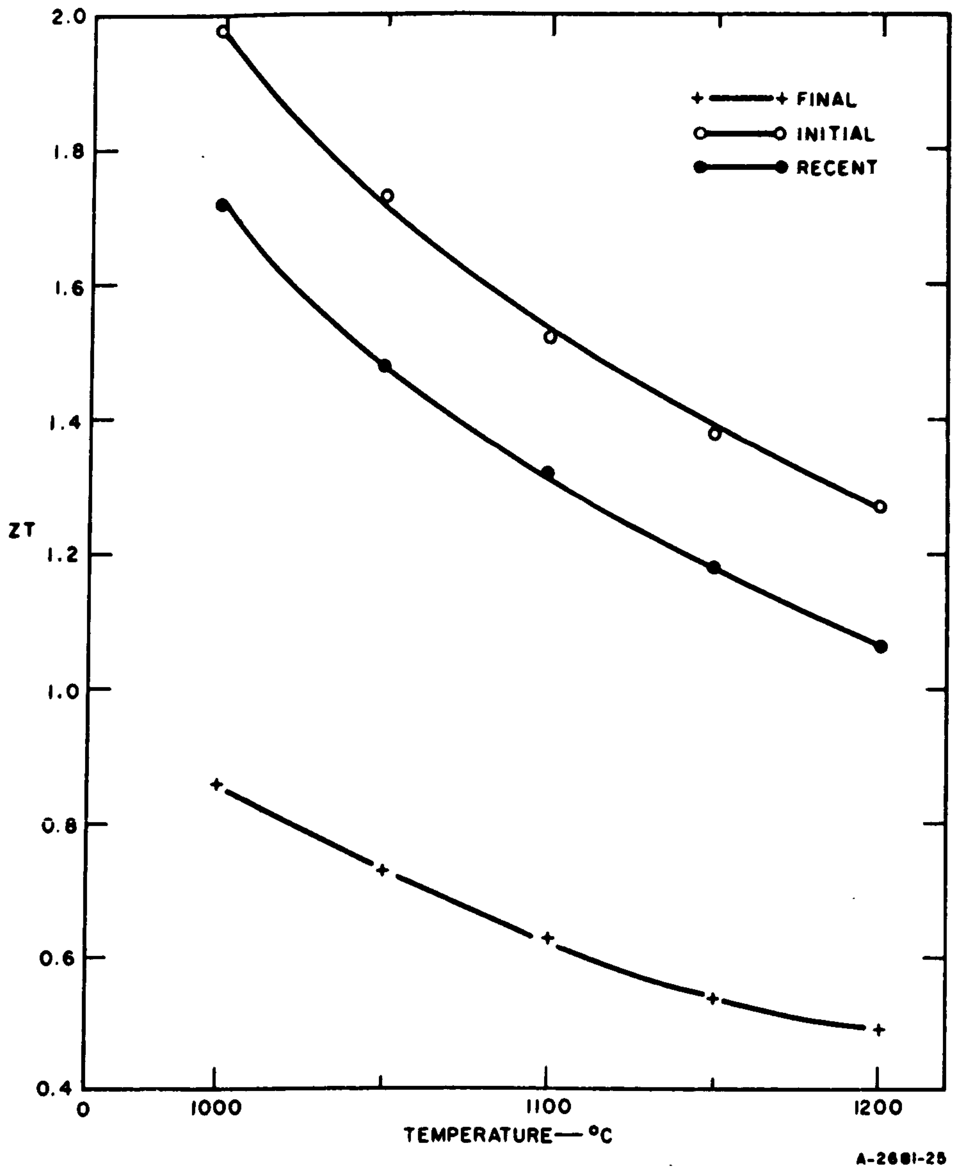

FINAL
INITIAL
RECENT
SEEBECK COEFFICIENT — μv/°C
250
200
150
RESISTIVITY — Ω-cm x 10³
6.0
5.0
4.0
3.0
2.0
1.0
0
S²/ρ x 10⁵
2.0
1.5
1.0
0.5
800
900
1000
1100
1200
TEMPERATURE — °C
B-2681-24

FIG. 1



FINAL
INITIAL
RECENT
ZT
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0
1000
1100
1200
TEMPERATURE — °C
A-2681-25

FIG. 2